State of California
Resources Agency
Department of Water Resources
Southern District
Resources Assessment Branch
Groundwater Section

Technical Information Record SD-07-02

An Interpretation of Geologic Materials Encountered in the Boring of Borrego Water District Monitoring Well MW-5

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This TIR is primarily a working paper and is subject to revision or replacement.

INTRODUCTION

Borrego Water District (BWD) monitoring wells numbered MW-5A and MW-5B were completed in June 2006 in Borrego Valley, located in northeastern San Diego County (Figure 1). The borehole for this dual completion well was drilled using the direct rotary method by So Cal Pump and Well Drilling. MW-5 (Figure 2) is located approximately 3.1 miles southeast of Borrego Valley Airport, 1.2 miles northeast of Borrego Sink, and about 150 feet north of dirt road that provides access to Borrego Spring which is located about one-half mile east of the well site within Anza-Borrego State Park. This monitoring well was drilled to obtain subsurface information near Borrego Sink and to establish a groundwater-level monitoring site. The water-level data will help constrain the groundwater gradient and facilitate calculations of subsurface flow out of the Borrego Valley groundwater basin.

The 14-inch diameter borehole for MW-5 was drilled to 480 feet below ground surface (bgs) and two 4-inch diameter wells were completed in the borehole. Well MW-5A was completed to 345 feet bgs and screened from 200 to 340 feet bgs (Table 1), and well MW-5B was completed to 160 feet bgs and screened from 45 to 155 feet bgs. BWD staff Jerry Rolwing and Greg Holloway attended the drilling, provided support, and assisted with sample collection. Tim Ross and Doug Ellis of the California Department of Water Resources (DWR), Southern District, recorded observations of drilling conditions and lithologic materials encountered during drilling and collected lithologic samples. This document provides an interpretation of the geology encountered in the borehole for MW-5 based on the Well Completion Report submitted by the driller, the electric logs produced by Pacific Surveys, and the observations of drilling conditions and descriptions of borehole cuttings and core samples collected during drilling recorded by DWR staff.

Table 1 – MW5 Completion Information

Local Well Number	State Well Number	Well Completion Report Number	Perforation Interval (Feet bgs)	UTM Location
MW5A	11S07E07R001S	1084529	200-345	11567000 E 3676820 N
MW5B	11S07E07R002S		45-155	

The borehole for MW-5 was spudded at about 1440 on Thursday, June 8, 2006. DWR staff were present and started collecting cuttings samples. A conductor hole was drilled to about 13 feet bgs, and conductor casing was set. The driller returned on June 13, 2006, and commenced drilling. DWR staff collected cuttings samples, which continued at 10-foot intervals throughout drilling. The materials were collected in triplicate and marked according to the depth of the drill bit at the time of sample collection. Darby Vickery (Engineering Geologist) of DWR Central District in Sacramento, DWR Southern District in Glendale, and BWD in Borrego Springs each received a set of samples. In addition, a coring bit was used to recover samples of the materials encountered at about 425 to 445 feet bgs. The recovered core is currently stored at the DWR Southern District office in Glendale.

In general, the boring encountered variably thick interbedded layers of coarser-grained materials (sand and gravel) with finer-grained materials (silt and clay). Based on the borehole cuttings and the geophysical logs, the geologic materials encountered can be separated into three main zones or sequences divided at prominent clay layers:

- An upper zone dominated by poorly consolidated coarse-grained materials from the surface to about 165 feet bgs.
- A middle zone of moderately consolidated, interbedded fine- and coarse-grained materials between about 165 feet and 355 feet bgs.
- A lower zone of consolidated or lithified beds of fine-grained and coarse-grained materials between 355 to 480 feet bgs.

DRILLING AND ELECTRIC LOG OBSERVATIONS

Geophysical well tools employed included the natural gamma, caliper, sonic velocity, short normal, long normal, and single point resistivity, spontaneous potential, and borehole televiewer. Pacific Surveys produced logs displaying information obtained by these tools in a variety of manners. Comparison of the characteristics of the logs with the observed material obtained by cuttings and with the core samples allows us to interpret the subsurface geology at this borehole.

Upper Zone:

The borehole spudded into surface deposits of fine-grained aeolian sand and silt. Cuttings from approximately the first 20 feet contain sandy, clayey silt grading to silty sand. Cuttings and geophysical logs indicate coarser, probably more sand-rich deposits with variable amounts of silt and clay down to about 165 feet bgs. The resistivity logs are interpreted to show a general layering of fining upward beds that are about 6 to 12 feet thick. The samples collected between about 110 and 160 bgs contained little clay and silt. The sonic log shows a change in formation velocity at about 60 feet bgs suggesting the interface between saturated and non-saturated materials. After well construction, the driller measured the static water level at 62 feet bgs, consistent with the sonic log. The shallow well (MW-5B) was completed in this upper zone of the boring.

Middle Zone:

At about 165 feet bgs, the natural gamma and resistivity logs suggest a layer of fine materials with a spike in the gamma response suggesting a clay layer about 15 feet thick. DWR staff observed a change from well-graded sands to high-plasticity clay at about 180 feet bgs. In comparison to the geophysical logs, it appears that there was a drilling lag for the clay to reach the surface and be collected that amounted to about 15 feet. The plastic clay sample contains streaks of reddish and greenish clays, establishing the first observation of encountering varicolored clays, which are noted in descriptions of the Palm Springs Group (e.g., Cassiliano 2002). This plastic clay layer appears to be about 15 feet thick, and the spike in gamma response may indicate an unconformity.

Below this clay, the character of the geophysical response to the materials present changes. The most prominent change is observed in the response of the resistivity tools. Below the clay layer, resistivity becomes generally lower with apparent coarser (sandier) layers having lower resistivity values than the materials encountered above 160 feet bgs. This change in resistivity may be caused by a change in dissolved solids in the groundwater, more consolidated materials, more fine materials, or a combination of these factors. The cuttings collected from about 170 feet through about 230 feet bgs typically consist of varicolored, plastic clays with coarse-grained sand or coarse-grained sand with varicolored clay lumps.

The cuttings sample collected at 230 feet bgs contains lumps of dry, light-colored clay and the sample collected at 240 feet bgs contains carbonate material and chips of claystone with carbonate cement. The cuttings samples from about 240 feet through 355 feet bgs contain variable mixtures of clay and sand. Geophysical logs show changes in character suggesting layering of clay, silt, and sands varying from about 2 to 5 feet in thickness. The logs can be interpreted to suggest a general increase in fine materials from about 270 feet through about 355 feet bgs. The occurrence of chips of claystone and siltstone, along with carbonate-cemented sands in the cuttings samples, suggest that this zone is more consolidated and more lithified than the upper zone of materials in this boring. Some of the layers in this zone have relatively high gamma response but show a relative rise in resistivity. The correlation of these responses is atypical and might be caused by dry, indurated claystone or shale beds, cemented sandstone, or limestone layers. The geophysical response and the observation of chips of dry lithified material suggests that these are layers of consolidated, dry claystone. Any such layers that are continuous and non-fractured would likely provide effective confining layers in this part of the basin. MW-5A is completed in this middle zone of the boring and by comparing water levels and pumping responses in MW-5A and MW-5B, we may be able to evaluate whether the middle zone is isolated from the upper zone.

Lower Zone:

Geophysical logs indicate that a distinct clay layer occurs from about 355 to 365 feet bgs. The gamma log shows a large spike, which suggests an unconformity at this depth. Below this clay layer, cuttings and geophysical logs are consistent with the occurrence of a sandstone layer about 10 to 12 feet thick. Below this sandstone, the geophysical logs generally show lower resistivities and higher gamma responses. These geophysical responses are consistent with an increase in silt and clay in the formation, a change of induration of the formation, or a change in character of the pore waters. At three depths in the lower zone, high gamma responses are coincident with high resistivity responses. The correlation of these responses is atypical is likely caused by dry, indurated claystone or shale beds.

Three coring runs were attempted in the lower zone. The first core produced about 8.15 feet of material from the interval between about 425 and 435 feet bgs. The core returned is dominantly massive, fine-grained, calcite-cemented sandstone with some layers of clay and sparse layers of silt. In some places, the sandstone contains layering of coarser and finer grains. This apparent bedding is observed to dip as much as about 30 degrees (the axis of the core is presumed to be vertical). Calcite nodules and layers also occur in this sample, with some of the layers appearing to dip similarly to the apparent bedding. The second core run produced about 5 feet of core from the interval between about 435 and 443 feet bgs. This core is dominantly fine-grained sandstone with calcite cement and some clay and veins of calcite present. Layering, defined by concentrations of biotite, is observed. This apparent bedding dips as much as about 50 degrees. The third core run produced about 8.7 feet of material from the interval between about 465 and 475 feet bgs. This core is a light greenish-gray, fine-grained sandstone with interbedded gray clay layers at the top. The materials become finer grained downward, and the lower portion of the core is dominantly brown, sheared clay with stringers and augen of dry, hard, light brown clay. The third core correlates with one of the atypical zones of higher gamma and higher resistivity, implying that the atypical geophysical response is likely correlated with dry, indurated claystone.

STRATIGRAPHY

Figure 3 shows generalized stratigraphic relationships for the Borrego region based on Cassiliano (2002) and Dorsey (2005) (see also Dibblee 1954; DWR 1964, 1968). The Imperial Formation consists of marine-deposited, light-gray claystone with minor arkosic-sandstone beds (Dibblee 1954; 1984). Fossil oyster beds and other tidal-marine invertebrate fossils are found in this formation. The Imperial Formation deposits are overlain by terrestrial deposits of the Plio-Pleistocene age Palm Spring Group (Cassiliano 2002).

The Canebrake Conglomerate, Olla Formation, and Arroyo Diablo Formation are roughly time equivalent facies of the lower part of the Palm Springs Group. The Canebrake Conglomerate is a coarse-grained facies that was derived from nearby mountains and deposited on alluvial fans near the exposed granitic and gneissic basement. This unit consists of gray pebble to cobble conglomerate and grades into and interfingers eastward with fluvial sands of the Olla Formation. The Olla Formation is interpreted to be a more distal facies of the alluvial fans of Canebrake affinity and interfingers eastward with the Arroyo Diablo Formation (Cassiliano 2002). The Arroyo Diablo Formation is interpreted to represent relatively fine-grained materials deposited dominantly in a deltaic environment by the ancestral Colorado River (Winker 1987; Cassiliano 2002). The Olla Formation is interpreted to be an interlayered system of sands and silts derived from a local source (the extension eastward of Canebrake Formation lithology) and from the Colorado River (the extension westward of Arroyo Diablo Formation lithology) (Winker 1987; Cassiliano 2002). The locally derived materials of the Olla Formation (L-suite of Winker 1987, or Canebrake affinity) “consist of light-gray to olive-gray sandstone, biotite-rich siltstone, and dark-olive siltstone and claystone” (Cassiliano 2002). The Colorado River derived sediments (C-suite of Winker, 1987) of the Arroyo Diablo Formation consist of orange, yellowish-brown, and reddish-brown sandstones with buff, gray, greenish-gray, and reddish-brown claystone and siltstone (Cassiliano 2002).

Dibblee (1984) interprets the Borrego Formation to comprise the upper part of the Palm Spring Group, stratigraphically overlying and interfingering with the Olla and Arroyo Diablo Formations. The Borrego Formation consists of a thick section of lucustrine claystone with minor thin-bedded tan to light-gray sandstone. These Palm Spring Group sediments are locally overlain by Pleistocene age Ocotillo Conglomerate and Brawley Formation and by younger Quaternary age aeolian and alluvial deposits.

INTERPRETATIONS

Fine- to coarse-grained sands interbedded with silt and clay are interpreted to dominate from ground surface to about 165 feet bgs. The upper portion of these sands may represent younger alluvial and aeolian deposits. Proceeding downward, these materials grade into older Quaternary age alluvium or a sand-rich portion of the Plio-Pleistocene Palm Spring Group (e.g., the Olla Formation lithology of Cassiliano 2002). The clay layer encountered at about 165 feet bgs contains reddish and greenish clays, implying that the borehole penetrated the Palm Spring Group by this depth. These varicolored clays, particularly in reddish to reddish-brown tones, are typical of the Arroyo Diablo Formation of the Palm Spring Group (Cassiliano 2002).

The section of the borehole between about 165 and 355 feet bgs is interpreted to contain interbedded sandstone, siltstone, and claystone. Reddish, greenish, yellowish-brown, dark-gray, and pinkish-white clay lumps were noted. Sand grains with red and orange staining were also observed. A comparison of the resistivity and gamma logs suggests that this section is dominated by moderately-thick (40 to 50 feet) layers that generally fine upward. The orange sands are typical of the Olla Formation and the varicolored clays are typical of the Arroyo Diablo Formation. The lithologies discussed above support the idea that the well is penetrating the Olla and Arroyo Diablo Formations somewhere within their overlapping portions.

A clay layer at about 355 feet bgs appears to mark a change in induration and perhaps an increase in clay content in the sediment. The gamma log shows a strong response at this clay layer which might be interpreted to indicate an unconformity at this position. Cemented sand was noted in the cuttings near this level and the core retrieved from the well at 425 feet bgs contains cemented sandstone and shale. An interesting electric response occurs at about 345 feet bgs, where the gamma log shows an increase, suggesting a clay layer, but the resistivity logs do not show a corresponding decrease that would be consistent with the clay layer being saturated. Because chips of hard, dry clay were collected from the cuttings above this drilling level, the gamma and resistivity logs may indicate that a dry, hard claystone bed occurs at about 345 feet bgs. This same log correlation occurs again deeper in the boring.

Beneath the clay layer at 355 feet bgs, the electric logs show a change in character. The resistivity logs show a decrease in overall resistivity. The position of maximum- and minimum-resistance measurements, which would likely correspond to the characteristics of sandy (maximum resistance) and clayey (minimum resistance) layers, both become lower. We interpret this change in electric character to have most likely been caused by a change in pore-water chemistry. The core that was retrieved from this borehole was obtained between 425 and 475 feet bgs. Those samples are composed of calcite-cemented sandstone, silty-sandstone, siltstone, and claystone beds. The degree of cementation indicates that there is low intergranular porosity and low specific yield associated with these materials. The lower section encountered in the borehole is most likely part of the Arroyo Diablo Formation of the Palm Spring Group. Orange sand grains typical of the Olla Formation were not observed, and coarse materials of the Canebrake conglomerate were not encountered.

There are several indications of highly indurated to lithified materials deeper than about 200 feet bgs. A white lump of clay that was dry inside was collected at a bit depth of about 230 feet bgs. Claystone and siltstone chips that fizzed with dilute HCl were collected at about 240 feet bgs. Chips of hard clay were noted at about 330 feet bgs. Clasts of cemented sand were observed from about 360 feet. When these observations are compared with the samples of cemented core from about 245 feet bgs and the character of the materials as interpreted from the electric logs, it appears that the materials are at least moderately indurated deeper than about 200 feet bgs and highly indurated and lithified deeper than about 360 feet bgs. Without confirmation of lithified formation provided directly by the core samples, it would have been more difficult to interpret that theses rocks are highly indurated at relatively shallow depths. The level of induration implies that the specific yield of these rocks is probably 5 or less percent (e.g. Olmsted and Davis 1961, DWR 1961), whereas, previous investigators have interpreted about 10 or higher percent specific yield in the Borrego Valley groundwater basin (Table 2). Because this is the first borehole for which we have core samples and a modern lithologic log, the scope of the implications of these observations is not known. However, based on previous models and estimates of specific yield for the basin, the southern part of the Borrego Valley groundwater basin may have a significantly lower storage capacity than previously proposed.

Table 2 – Previous Estimates of Specific Yield for Borrego Valley Groundwater Basin

Specific Yield Estimate	Reference
12 percent (basin)	U. S. Bureau of Reclamation 1968
13 percent (basin)	Lough 1974
12 percent (south), 13.3 percent (basin)	Phoenix 1979
10 percent (middle aquifer)	Moyle 1982
10.8 percent (south), 13.6 percent (basin)	DWR Southern District unpublished

WATER QUALITY

BWD staff collected samples of water from wells MW-5A and MW-5B on December18, 2006. Analysis of the water samples was conducted by the laboratory of E. S. Babcock and Sons and is presented below in Table 3. The analyses indicate that both wells have sodium sulfate type water and that water from the upper completion (MW-5B) has lower total dissolved solids (TDS) content (1300 mg/L) than does water from the lower completion (MW-5A) which has a TDS content of 2300 mg/L. The water from both wells is saturated with calcite, consistent with the observed calcite-cemented claystone and sandstone. The high TDS content and high sulfate content make the water from both wells unsuitable for drinking water supply without additional treatment.

CONCLUSIONS

Borehole MW-5 was drilled to a depth of about 480 feet bgs, and two wells were completed. The uppermost portion of the borehole appears to penetrate interbedded layers of sand, silt, and clay. These materials may be Quaternary alluvial deposits or possibly the upper portion of the Palm Spring Group. By 165 feet bgs, the borehole had penetrated distinctive varicolored clays typical of the Arroyo Diablo Formation. This borehole appears to have continued to penetrate Palm Spring Group materials to the total depth. Below about 200 feet bgs, the formation becomes increasingly indurated and lithified. Core samples taken from 425 feet bgs confirm the existence of cemented sandstone.

The character of the core samples highlights the potential error in interpreting hydrogeologic characteristics of materials derived only using a lithologic log. Because this project produced the first core available from the Borrego Valley groundwater basin, it provides an important check on the traditional methods used to interpret specific yield and other aquifer characteristics in this groundwater basin and in other groundwater basins in the State. The interpretation of observations made during the drilling of MW-5 imply that there may be substantially less water in storage in Borrego Valley groundwater basin than previously interpreted. Additional collecting of core samples and careful logging of wells is necessary to re-evaluate the distribution of specific yield and other aquifer characteristics in the southern portion of Borrego Valley.

Table 3 – Water Quality Analysis of MW5

CONSTITUENT CATIONS	**MW-5B**	**MW-5A**	**Units**
Hardness	280	530	mg/L
Calcium	76	140	mg/L
Magnesium	22	41	mg/L
Sodium	340	600	mg/L
Potassium	11	12	mg/L
Total Cations	20.6	37.7	me/L
ANIONS			
Total Alkalinity	80	76	mg/L
Hydroxide	ND	ND	mg/L
Carbonate	ND	ND	mg/L
Bicabonate	98	93	mg/L
Chloride	180	300	mg/L
Sulfate	700	1200	mg/L
Nitrate as N	ND	ND	mg/L
Fluoride	1.3	0.8	mg/L
Total Anions	ND	35.01	me/L
AGGREGATE PROPERTIES			
pH	8	7.6	pH units
Specific Conductance	2100	3300	umhos/cm
SOLIDS			
Total Dissolved Solids	1300	2300	mg/L
GENERAL INORGANICS			
Cyanide	ND	ND	mg/L
METALS AND METALLOIDS			
Mercury	ND	ND	ug/L
Aluminum	55	ND	ug/L
Antimony	ND	ND	ug/L
Arsenic	3.9	ND	ug/L
Barium	ND	ND	ug/L
Cadmium	ND	ND	ug/L
Total Chromium	ND	ND	ug/L
Copper	ND	12	ug/L
Iron	1300	24	ug/L
Lead	ND	ND	ug/L
Manganese	160	160	ug/L
Nickel	ND	ND	ug/L
Selenium	ND	6.1	ug/L
Silver	ND	ND	ug/L
Thallium	ND	ND	ug/L
Zinc	130	30	ug/L

References Cited:

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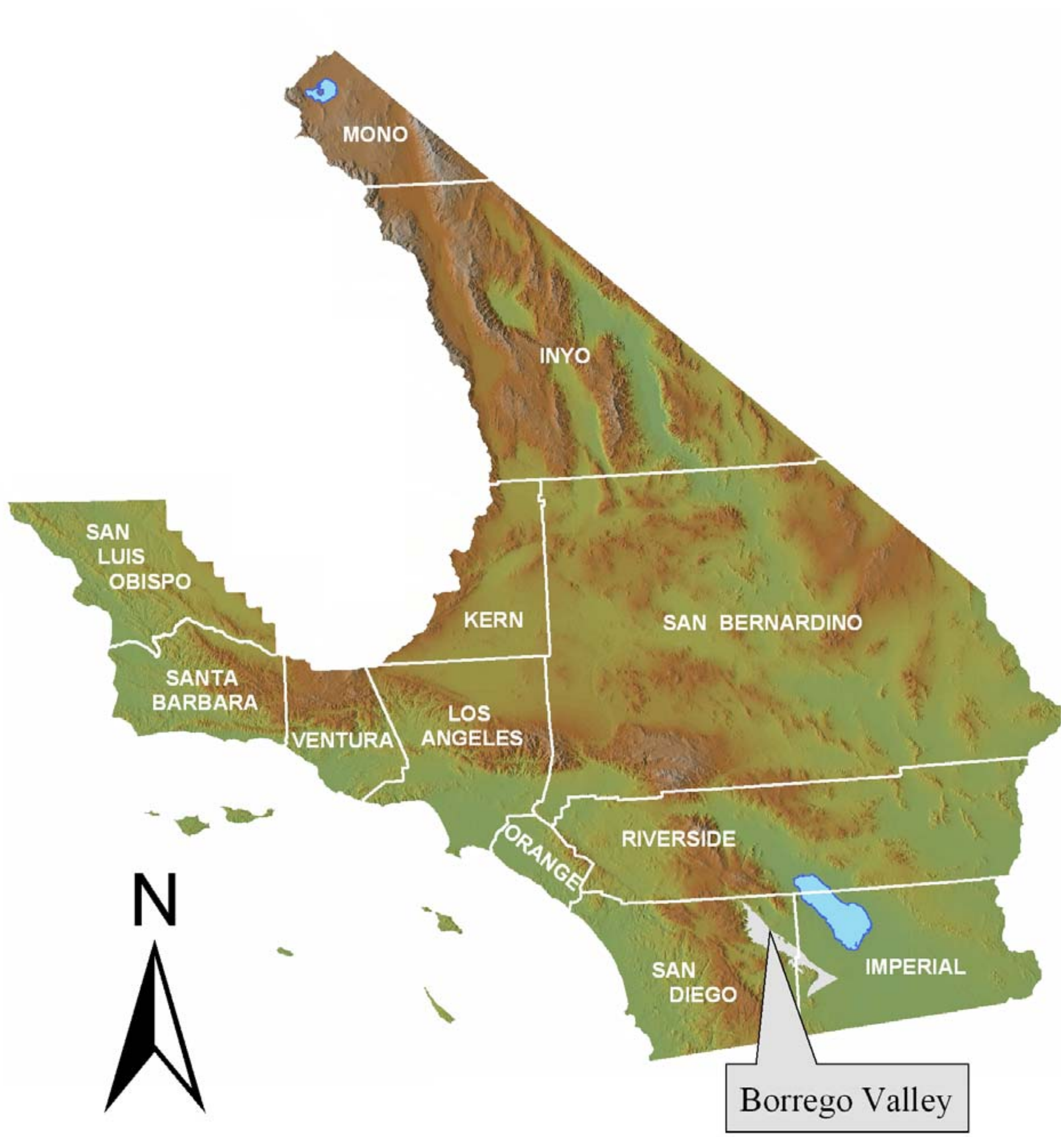

Figure 1. Location of Borrego Valley in southern California.

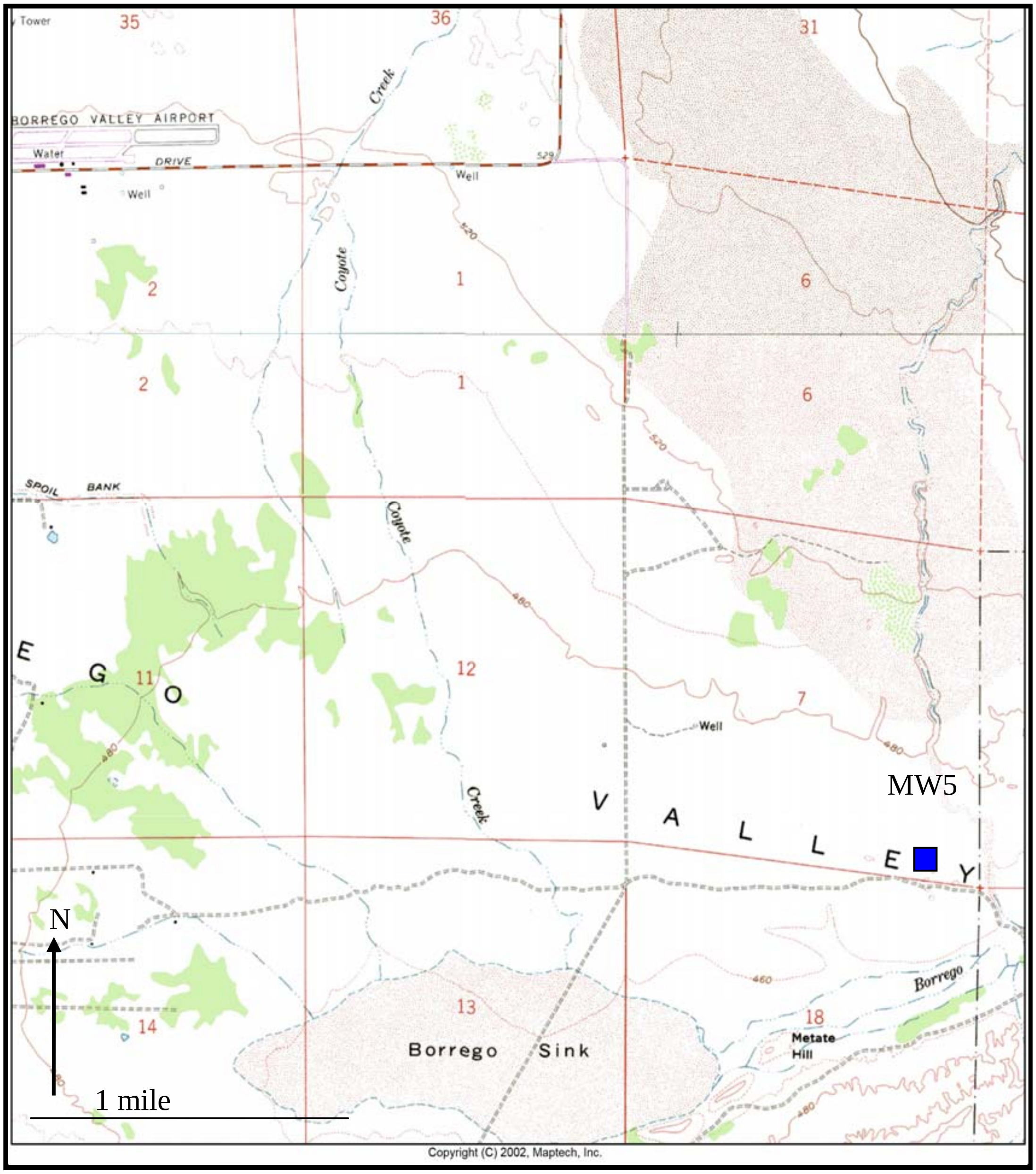

Figure 2. Location of Well MW-5 in Borrego Valley.

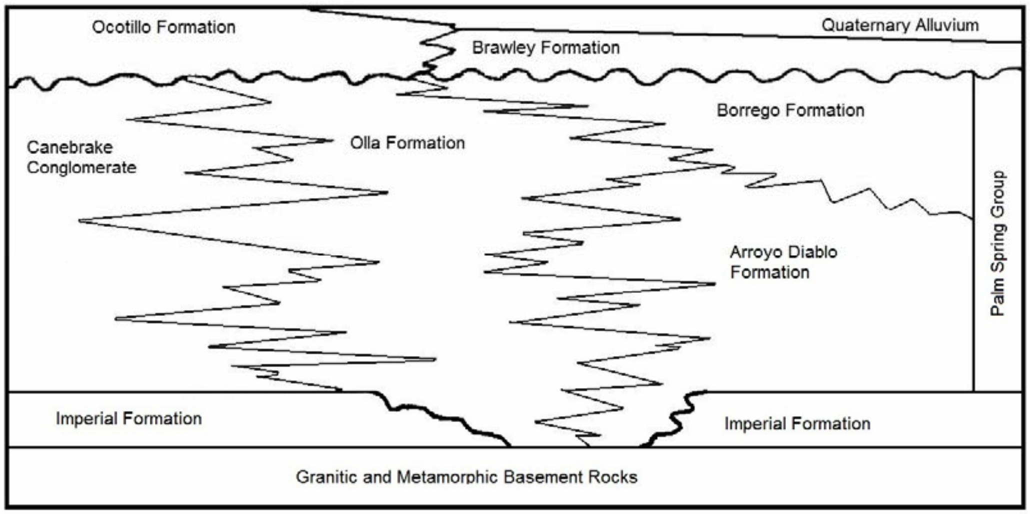

Figure 3. Generalized Stratigraphy of the Borrego Badlands area (adapted from Cassiliano 2002, and Dorsey 2005).

Appendix A:

MW-5 Geophysical log showing Gamma, Spontaneous Potential, and Resistivity tool responses by Pacific Surveys.

PACIFIC SURVEYS

ELECTRIC LOG GAMMA-RAY

Job No.	12614
File No.	
Company	SO CAL PUMP & WELL
Well	BORREGO MW5
Field	BORREGO SPRINGS
County	SAN DIEGO
State	CA

Location:
2 miles S. of Palm Canyon Drive
& Peg Leg Road
SE 1/4

Sec. 7 Twp. 11S Rge. 7E

Other Services:
SONIC/VDL
BHTV
CALIPER

Permanent Datum	G.L	Elevation 465'
Log Measured From	G.L	0' above perm. datum
Drilling Measured From	G.L	

Elevation
K.B.
D.F.
G.L.

Date	06-20-06		
Run Number	ONE		
Depth Driller	480'		
Depth Logger	481'		
Bottom Logged Interval	481'		
Top Log Interval	0'		
Casing Driller	16' @ 13'		
Casing Logger	13'		
Bit Size	7 7/8"		
Type Fluid in Hole	BENTONITE		
Density / Viscosity	NA		
pH / Fluid Loss	NA		
Source of Sample	PIT		
Rm @ Meas. Temp	9.8 @ 77F		
Rmf @ Meas. Temp	8.65 @ 77F		
Rmc @ Meas. Temp	NA		
Source of Rmf / Rmc	MEAS		
Rm @ BHT	NA		
Time Circulation Stopped	0 HRS		
Time Logger on Bottom	19:30		
Max. Recorded Temperature	NA		
Equipment Number	PS-3		
Location	L.A.		
Recorded By	TRAD/RIDDER		
Witnessed By	Tim Ross		

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Comments

ELOG Calibration Report

Serial:	D4
Model:	DTQ
Shop Calibration Performed:	Fri Jan 13 10:44:57 2006

Before Survey Verification Performed:	Fri Jan 13 10:44:59 2006
After Survey Verification Performed:	Fri Jan 13 10:45:04 2006

Shop Calibration

	Readings			References			Results	
	Zero	Cal		Zero	Cal		Gain	Offset
Short	8.639	100.407		10.200	102.200	Ohm-m	1.003	1.539
Long	5.418	94.588		10.200	102.200	Ohm-m	1.032	-17.315
IEE	7094.720	7147.780	counts	7.764	7.823	A		
VSN	8069.680	8131.900	counts	153.919	155.106	V		
VLN	2049.980	2059.220	counts	39.101	39.277	V		

Before Survey Verification

	Readings			References			Results	
	Zero	Cal		Zero	Cal		Gain	Offset
Short	101.284	101.286		101.238	101.262	Ohm-m	10.606	-972.995
Long	102.574	102.569		102.569	102.569	Ohm-m	68.614	-6935.150
IEE	7177.640	7188.640	counts	7.855	7.867	A		
VSN	8167.660	8180.360	counts	155.788	156.030	V		
VLN	2067.920	2071.000	counts	39.443	39.502	V		

After Survey Verification

	Readings			References			Results	
	Zero	Cal		Zero	Cal		Gain	Offset
Short	101.291	101.291		101.284	101.286	Ohm-m	5.546	-460.437
Long	102.568	102.559		102.569	102.569	Ohm-m	0.563	44.827
IEE	7216.000	7220.860	counts	7.897	7.903	A		
VSN	8211.900	8217.460	counts	156.632	156.738	V		
VLN	2078.860	2080.080	counts	39.652	39.675	V		

After Survey Verification compared to Before Survey Calibration

	Zero			Cal		
	Before	After		Before	After	
Short	101.238	101.284	Ohm-m	101.262	101.286	Ohm-m
Long	102.872	102.574	Ohm-m	102.569	102.569	Ohm-m

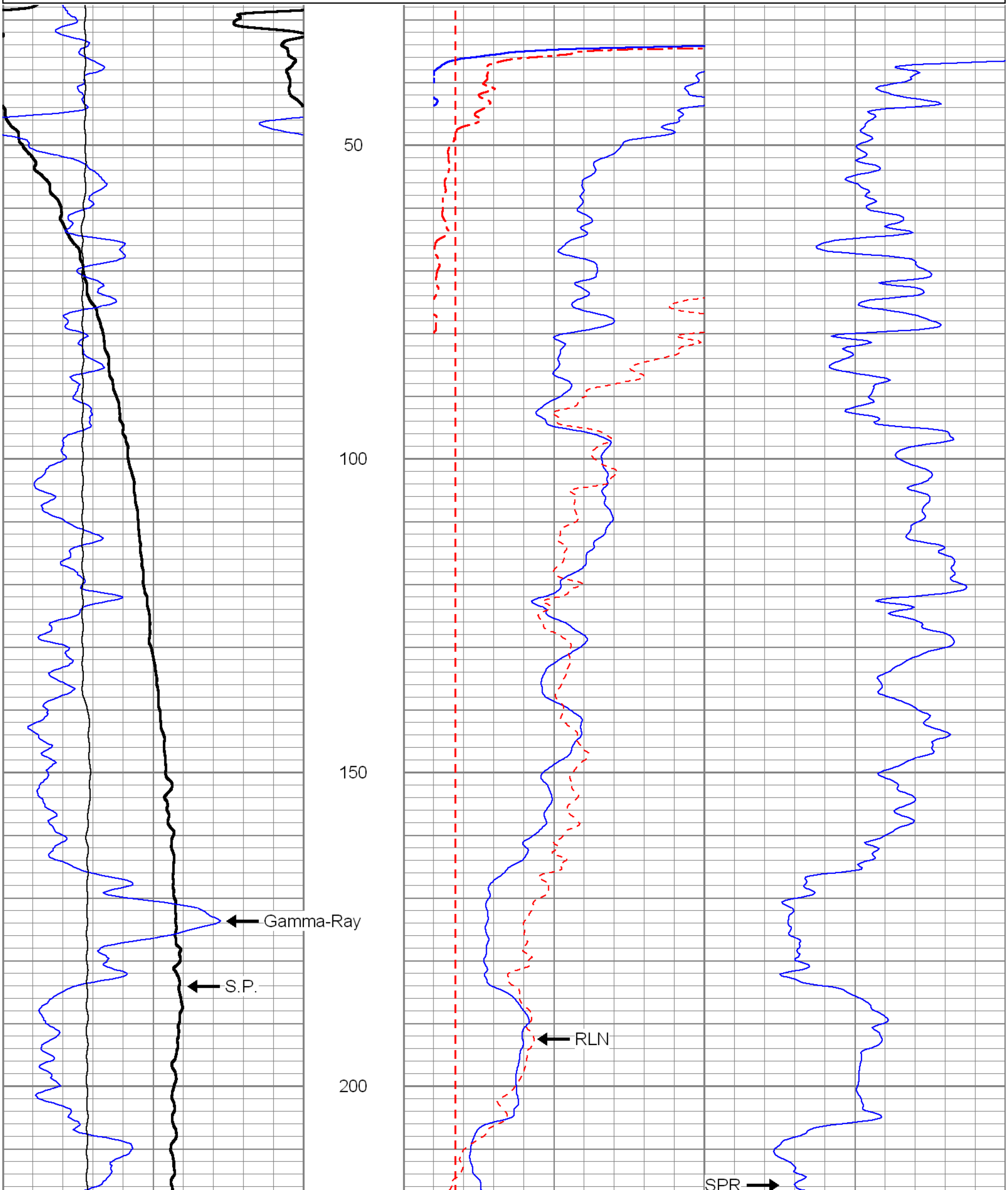
Gamma Ray Calibration Report

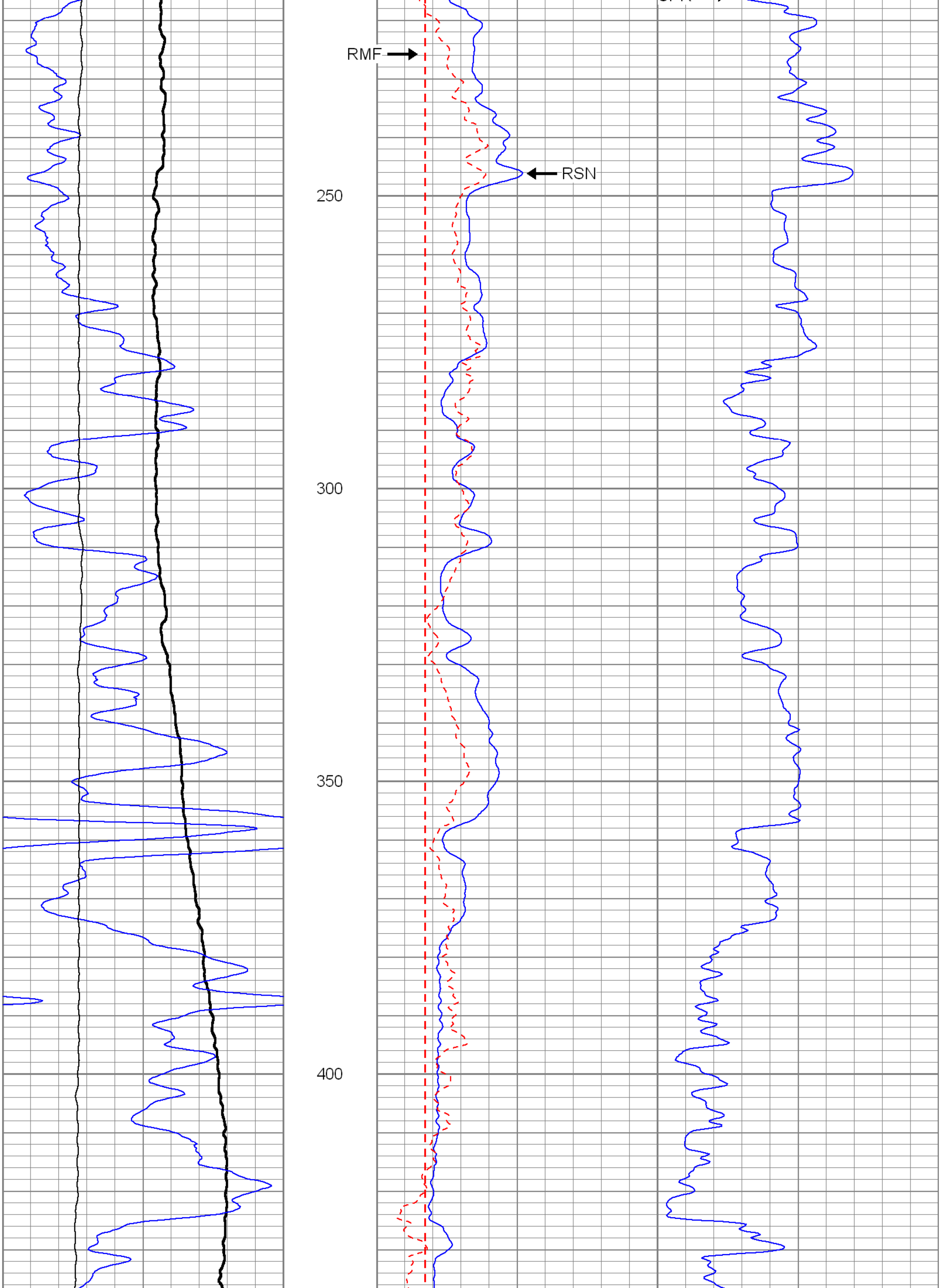
Serial Number:	D4	
Tool Model:	ELOG	
Performed:	Fri Jan 13 10:45:11 2006	
Calibrator Value:	162.0	GAPI
Background Reading:	172.5	cps
Calibrator Reading:	717.9	cps
Sensitivity:	0.2970	GAPI/cps

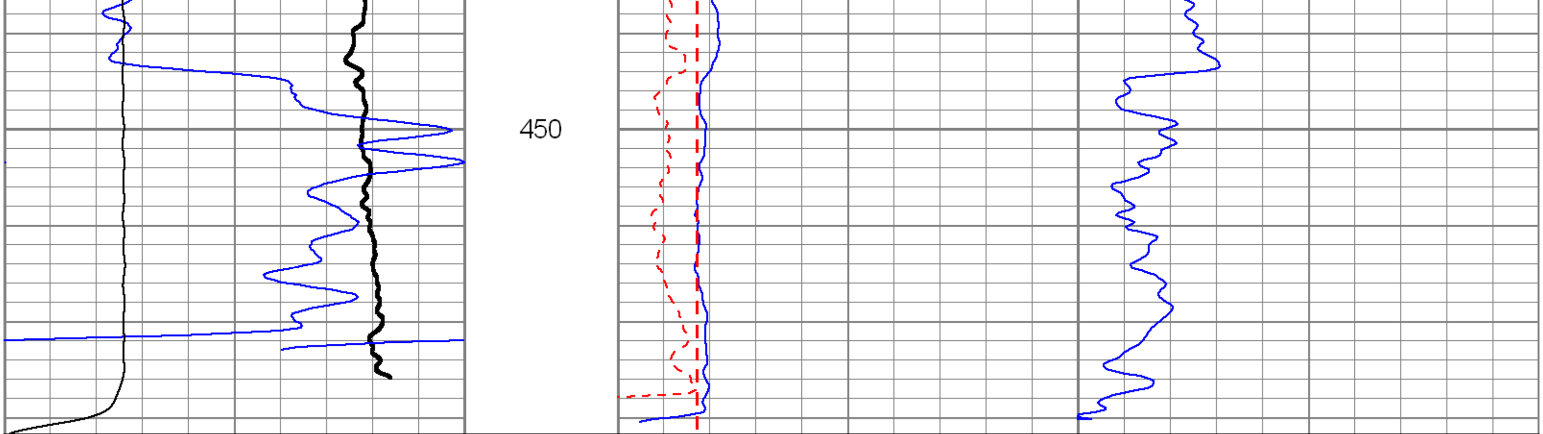
Database File:	12614.db
Dataset Pathname:	SOCAL/MW5/run1/ELOG
Presentation Format:	elog2
Dataset Creation:	Tue Jun 20 19:27:53 2006 by Log Warrior 7.0 STD Ope

Charted by: Depth in Feet scaled 1:240

-160 S.P. (mV) 30		0 RSN (Ohm-m) 50		10 SPR (Ohm-m) 70	
40 Gamma-Ray (GAPI) 140		0 RLN (Ohm-m) 50			
0 Line Speed (ft/min) -100		0 RMF (Ohm-m) 50			
		50 RSN back-up (Ohm-m) 500			
		50 RLN back-up (Ohm-m) 500			




RMF
RSN
250
300
350
400



-160	S.P. (mV)	30	0	RSN (Ohm-m)	50	10	SPR (Ohm-m)	70
40	Gamma-Ray (GAPI)	140	0	RLN (Ohm-m)	50			
0	Line Speed (ft/min)	-100	0	RMF (Ohm-m)	50			
			50	RSN back-up (Ohm-m)	500			
			50	RLN back-up (Ohm-m)	500			